

control circuits for controlling the first and second pulse
width modulators responsive to the feedback circuit, the
operation of the first and second pulse width modulators being
interleaved;

the control circuits also being responsive to the difference in <u>currents</u> [current] through the first converter and the second converter to adjust the relative duty cycle of the first and second converters to tend to minimize the difference in the voltage across <u>a</u> [the] sense resistor;

[the current sense circuit,] the first pulse width modulator, the second pulse width modulator, the feedback circuit and the control circuits being in a single integrated circuit.

- 13. (Amended) The DC to DC switching circuit of claim 12
- 2 further comprised of an integrator having an output responsive to
- 3 the integral of an error signal, the error signal being
- 4 responsive to the voltage across the common load and a desired
- 5 voltage, the control circuits also being responsive to the output
- 6 of the integrator.

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1	22. (New) A DC to DC converter having a plurality of
2	converter circuits for operating into a common load, comprising:
. 3	a plurality of buck converter circuits operating into the
4	common load, each buck converter circuit having an inductor for
5	alternately conducting between the first power supply terminal
6	and the common load, and the second power supply terminal and the
7	common load;
8	a plurality of pulse width modulators driven by a common
9	oscillator in an interleaved manner, each pulse width modulator
10	controlling one of the plurality of buck converter circuits,
11	whereby the operation of the buck converter circuits is
12	interleaved;
13	a feedback circuit responsive to a voltage across the common
14	load;
15	a voltage control circuit controlling the plurality of pulse
16	width modulators responsive to the feedback circuit and a
17	commanded output voltage; and
18	a current balance control circuit responsive to the
19	difference in currents in the plurality of interleaved buck
20	converter circuits and controlling the pulse width modulators to
21	balance the currents in the plurality of interleaved buck
22	converter circuits;
23	the plurality of pulse width modulators and the control
~ 24	circuits being in a single integrated circuit.

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24.	(New)	The	DC	to	DC	converter	of	claim	22	further

- 2 comprised of an integrator having an output responsive to the
- 3 integral of an error signal, the error signal being responsive to
- 4 the voltage across the common load and a desired voltage, the
- 5 control circuits also being responsive to the output of the
- 6 integrator.

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- 1 25. (New) The DC to DC converter of claim 24 wherein a
- 2 time constant of the integrator is adjustable by the selection of
- 3 at least one component external to the integrated circuit.

1 26. (New) The DC to DC converter of claim 24 further

- 2 comprised of a differentiator having an output responsive to the
- 3 rate of change of the voltage across the common load, the control
- 4 circuits also being responsive to the output of differentiator.
- 1 27. (New) The DC to DC converter of claim 26 wherein the
- 2 time constant of the differentiator is adjustable by the
- 3 selection of at least one component external to the integrated
- 4 circuit.

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28. (New) The DC to DC converter of claim 22 wherein the

- 2 control circuits are also responsive to rapid decreases in the
- .3 voltage across the common load to turn on the plurality of buck

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4	converter	circuits	independent	of	the	phase	of	the	plurality	of of
	•									
5	pulse wid	th modulat	cors.							

1 28. (New) The DC to DC converter of claim 28 wherein the
2 control circuits are also responsive to rapid increases in the
3 voltage across the common load to turn off the plurality of buck
4 converter circuits independent of the phase of the plurality of

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20. (New) The DC to DC converter of claim 22, wherein the plurality of pulse width modulators consist of a pair of pulse

3 width modulators.

pulse width modulators.

1 31. (New) The DC to DC converter of claim 22 wherein the
2 feedback circuit is in the single integrated circuit.

1 2. (New) A DC to DC converter having a plurality of

2 converter circuits operating into a common load, comprising:

a plurality of buck converter circuits operating into the

4 common load, each buck converter circuit having an inductor for

5 alternately conducting between the first power supply terminal

6 and the common load, and the second power supply terminal and the

7 common load;

a plurality of pulse width modulators each controlling one

of the plurality of buck converter circuits, the operation of the

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	10	pulse width modulators and the buck converter circuits being
	11	interleaved;
1	12	a feedback circuit responsive to a voltage across the common
$\setminus \mid$	13	load;
' '	14	control circuits responsive to the feedback circuit and a
	15	commanded output voltage to control a nominal duty cycle of the
	16	plurality of buck converter circuits, the control circuits also
	17	being responsive to the difference in currents in the plurality
	18	of interleaved buck converter circuits to adjust relative duty
	19	cycles of the plurality of buck converter circuits to balance the
	20	currents in the buck converter circuits;
	21	the plurality of pulse width modulators and the control
	22	circuits being in a single integrated circuit.
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	1	24. (New) The DC to DC converter of claim 32 wherein the
	2	control circuits control the plurality of pulse width modulators.

The DC to DC converter of claim 32 further (New)

- comprising an integrator having an output responsive to the
- integral of an error signal, the error signal being responsive to 3
- the voltage across the common load and a desired voltage.

The DC to DC converter of claim 25, wherein the (New)

2 control circuits are also responsive to the output of the

3 integrator.

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1	. (New) The DC to DC converter of claim 25 wherein a
2	time constant of the integrator is adjustable by the selection of
3	at least one component external to the integrated circuit.
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1	33 W. (New) The DC to DC converter of claim at further
2	comprising a differentiator having an output responsive to a rate
3	of change of the voltage across the common load, the control
4	circuits also being responsive to the output of differentiator.
•	cifedites also selling respensive to the self-
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1	(New) The DC to DC converter of claim 28 wherein a
2	time constant of the differentiator is adjustable by the
3	selection of at least one component external to the integrated
4	circuit.
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1	20 (New) The DC to DC converter of claim 32 wherein the
2	control circuits are also responsive to rapid decreases in the
3	voltage across the common load to turn on the plurality of buck
4	converter circuits, independent of the phase of the plurality of
5	pulse width modulators.
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1	47. (New) The DC to DC converter of claim 3% wherein the
2	control circuits are also responsive to rapid increases in the
3	voltage across the common load to turn off the plurality of buck
4	converter circuits, independent of the phase of the plurality of
_ 5	pulse width modulators.

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1 Mew) The DC to DC converter of claim 32, wherein the
2 plurality of pulse width modulators consist of a pair of pulse

3 width modulators.

1 43. (New) The DC to DC converter of claim 22 wherein the
2 commanded output voltage is controllable through an input to the

3 integrated circuit.

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14. (New) The DC to DC converter of claim 32 wherein the

2 feedback circuit is in the single integrated circuit.

1 (New) A DC to DC converter having a plurality of

2 converter circuits operating into a common load, comprising:

a plurality of buck converter circuits operating into the

4 common load, each buck converter circuit having an inductor for

alternately conducting between the first power supply terminal

6 and the common load, and the second power supply terminal and the

7 common load;

a plurality of pulse width modulators each controlling one

9 of the plurality of buck converter circuits, the operation of the

10 pulse width modulators being interleaved;

control circuits for adjusting a nominal duty cycle of the

12 plurality of interleaved buck converter circuits, the control

13 circuits also being responsive to the difference in currents in

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the plurality of	interleaved	buck	converter	circuits	to	adjust

- 15 the relative duty cycles of the plurality of buck converter
- 16 circuits to balance the currents therein;
- the plurality of pulse width modulators and the control
- 18 circuits being in a single integrated circuit.
 - 1 46. (New) A DC to DC converter having first and second
- 2 converter circuits operating into a common load, comprising:
- 3 first and second buck converter circuits operating into the
- 4 common load, each buck converter circuit having an inductor for
- 5 alternately conducting between the first power supply terminal
- 6 and the common load, and the second power supply terminal and the
- 7 common load;
- a first pulse width modulator controlling the first buck
- 9 converter circuit;
- a second pulse width modulator controlling the second buck
- 11 converter circuit;
- a feedback circuit responsive to the voltage across the
- 13 common load;
- 14 control circuits for controlling the first and second pulse
- 15 width modulators responsive to the feedback circuit;
- the control circuits also being responsive to current
- 17 measurements in the first buck converter circuit and the second
- 18 buck converter circuit for adjusting the relative duty cycle of



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	·
	the first and second pulse width modulators to balance the
	currents in the buck converter circuits;
	the first pulse width modulator, the second pulse width
ļ	modulator, the feedback circuit and the control circuits being in
	a single integrated circuit.
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	(New) A DC to DC converter having a plurality of
-	converter circuits operating into a common load, comprising:
	a plurality of buck converter circuits operating into the
	common load, each buck converter circuit having an inductor for
	alternately conducting between the first power supply terminal
3	and the common load, and the second power supply terminal and the
	common load;
	a plurality of pulse width modulators driven by a common
	oscillator in an interleaved manner, each pulse width modulator
	controlling one of the plurality of buck converter circuits,
	whereby the operation of the buck converter circuits is
	<pre>interleaved;</pre>
	a feedback circuit responsive to a voltage across the common
	load;
	a voltage control circuit for controlling the plurality of
	pulse width modulators responsive to the feedback circuit and a
	commanded output voltage; and

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a current balance control circuit responsive to the

difference in currents in the plurality of interleaved buck

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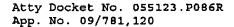


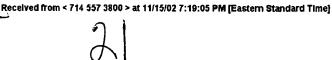


20	converter	circuita	for	controlling	the	pulse	width	modulators	to
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- 21 balance the currents in the plurality of interleaved buck
- 22 converter circuits;
- the plurality of pulse width modulators, the feedback
- 24 circuit, the voltage control circuit and the current balance
- 25 control circuit being in a single integrated circuit.

- 1 48. (New) A DC to DC converter having a plurality of
- 2 converter circuits operating into a common load, comprising:
- a plurality of buck converter circuits operating into the
- 4 common load, each buck converter circuit having an inductor for
- 5 alternately conducting between the first power supply terminal
- 6 and the common load, and the second power supply terminal and the
- 7 common load;
- a plurality of pulse width modulators each controlling power
- 9 switching devices of one of the plurality of interleaved buck
- 10 converter circuits, the operation of the pulse width modulators
- 11 and the buck converter circuits being interleaved;
- 12 a feedback circuit responsive to a voltage across the common
- 13 load;
- 14 control circuits responsive to the feedback circuit and a
- 15 commanded output voltage to control a nominal duty cycle of the
- 16 plurality of buck converter circuits, the control circuits also
- 17 being responsive to the difference in currents in the plurality
- 18 of interleaved buck converter circuits to adjust the relative





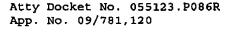


19	duty	cvcles	of	the	plurality	of	buck	converter	circuits	to
			_		<u> </u>					

- 20 balance the currents in the buck converter circuits;
- 21 the plurality of pulse width modulators, the feedback
- 22 circuit and the control circuits being in a single integrated
- 23 circuit.

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- 49. (New) A DC to DC converter having a plurality of
- 2 converter circuits operating into a common load, comprising:
- a plurality of buck converter circuits operating into the
- 4 common load, each buck converter circuit having an inductor for
- 5 alternately conducting between the first power supply terminal
- 6 and the common load, and the second power supply terminal and the
- 7 common load;
- a plurality of pulse width modulators each controlling one
- 9 of the plurality of buck converter circuits, the pulse width
- 10 modulators being driven by a common oscillator signal so that the
- operation of the pulse width modulators is interleaved;
- control circuits for adjusting a nominal duty cycle of the
- 13 plurality of interleaved buck converter circuits to control a
- 14 voltage on the common load, and for responding to the difference
- 15 in currents in the plurality of interleaved buck converter
- 16 circuits to adjust the relative duty cycles of the plurality of
- 17 buck converter circuits to balance the currents in the buck
- 18 converter circuits;







and the

 19	the plurality of pulse width modulators and the control
20	circuits being in a single integrated circuit.
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1	50. (New) A DC to DC converter having first and second
2	converter circuits operating into a common load, comprising:
3	first and second buck converter circuits operating into the
4	common load, each buck converter circuit having an inductor for
5	alternately conducting between the first power supply terminal
6	and the common load, and the second power supply terminal and the
7	common load;
8	a first pulse width modulator controlling the first buck
9	<pre>converter circuit;</pre>
10	a second pulse width modulator controlling the second buck
11	converter circuit;
12	a feedback circuit responsive to the voltage across the
13	common load;
14	control circuits for controlling the first and second pulse
15	width modulators responsive to the feedback circuit;
16	the control circuits also being responsive to current
17	measurements through the first buck converter circuit and the
18	second buck converter circuit to adjust the relative duty cycle
19	of the first and second buck converter circuits

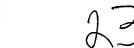
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the first pulse width modulator, the second pulse width

modulator and the control circuits being in a single integrated

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circuit.

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51. (New) A DC to DC converter comprising:

- 2 a plurality of buck converter circuits operating into the
- 3 common load, each buck converter circuit having an inductor for
- 4 alternately conducting between the first power supply terminal
- 5 and the common load, and the second power supply terminal and the
- 6 common load;
- 7 a plurality of pulse width modulators driven by a common
- 8 oscillator in an interleaved manner, each pulse width modulator
- 9 controlling one of the plurality of buck converter circuits,
- 10 whereby the operation of the buck converter circuits is
- 11 interleaved;
- a feedback circuit responsive to a voltage on the common
- 13 output;
- a voltage control circuit for controlling the plurality of
- 15 pulse width modulators responsive to the feedback circuit and a
- 16 commanded output voltage; and
- 17 a current balance control circuit for controlling the pulse
- 18 width modulators responsive to a difference in currents in the
- 19 inductors of the plurality of interleaved buck converter circuits
- 20 to balance the currents in the plurality of interleaved buck
- 21 converter circuits;
- 22 the plurality of pulse width modulators and the control
- 23 circuits being in a single integrated circuit.



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	5	alternately conducting between the first power supply terminal
	6	and the common load, and the second power supply terminal and the
	7	common load;
	8	a plurality of pulse width modulators each controlling power
	9	switching devices of one of the plurality of buck converter
	10	circuits, the operation of the pulse width modulators and the
5	11	buck converter circuits being interleaved;
	12	a feedback circuit responsive to a voltage across the common
	13	load;
1	14	control circuits being responsive to the feedback circuit
	15	and a commanded output voltage to control a nominal duty cycle of
	16	the plurality of buck converter circuits, the control circuits
	17	also being responsive to the difference in currents in the
	18	plurality of interleaved buck converter circuits to adjust the
	19	relative duty cycles of the plurality of buck converter circuits

to balance the currents in the buck converter circuits;

circuits being in a single integrated circuit.

(New) A DC to DC converter having a plurality of

a plurality of buck converter circuits operating into the

common load, each buck converter circuit having an inductor for

converter circuits operating into a common load, comprising:



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the plurality of pulse width modulators and the control

(New)

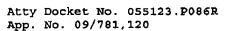
2	converter circuits operating into a common load, comprising:
3	first and second buck converter circuits operating into the
4	common load, each buck converter circuit having an inductor for
5	alternately conducting between the first power supply terminal
6	and the common load, and the second power supply terminal and the
7	common load;
8	a first pulse width modulator controlling the first buck
9	<pre>converter circuit;</pre>
10	a second pulse width modulator controlling the second buck
11	<pre>converter circuit;</pre>
12	a feedback circuit responsive to the voltage across the
13	common load;
14	control circuits for controlling the first and second pulse
15	width modulators responsive to the feedback circuit;
16	the control circuits also being responsive to current
17	measurements in the first buck converter circuit and the second
18	buck converter circuit to adjust the relative duty cycle of the
19	first and second buck converter circuits;

A DC to DC converter having first and second



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a single integrated circuit.



the first pulse width modulator, the second pulse width

modulator, the feedback circuit and the control circuits being in



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54. (New) A DC to DC converter having a plus	rality of
converter circuits operating into a common load, co	omprising:
a plurality of buck converter circuits operat:	ing into the

- 4 common load, each buck converter circuit having an inductor for 5 alternately conducting between the first power supply terminal
- 6 and the common load, and the second power supply terminal and the
- 7 common load;

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- a plurality of pulse width modulators driven by a common
- 9 oscillator in an interleaved manner, each pulse width modulator
- 10 controlling one of the plurality of buck converter circuits,
- 11 whereby the operation of the buck converter circuits is
- 12 interleaved;
- a feedback circuit responsive to a voltage across the common
- 14 load;
- a voltage control circuit for controlling the plurality of
- 16 pulse width modulators responsive to the feedback circuit and a
- 17 commanded output voltage; and
- a current balance control circuit for controlling the pulse
- 19 width modulators to balance the currents in the plurality of
- 20 interleaved buck converter circuits responsive to the difference
- 21 in currents in the plurality of interleaved buck converter
- 22 circuits;



the plurality of pulse width modulators, the voltage control 23 circuit and the current balance control circuit being in a single 24 25 integrated circuit. 53 (New) A DC to DC converter having a plurality of 1 converter circuits operating into a common load, comprising: 2 a plurality of buck converter circuits operating into the 3 common load, each buck converter circuit having an inductor for 4 alternately conducting between the first power supply terminal 5 and the common load, and the second power supply terminal and the б 7 common load; a plurality of pulse width modulators each controlling power 8 switching devices of one of the plurality of interleaved buck 9 converter circuits, the operation of the pulse width modulators 10 and the buck converter circuits being interleaved; 11 a feedback circuit responsive to a voltage across the common 12 load; 13 control circuits responsive to the feedback circuit and a 14 commanded output voltage to control a nominal duty cycle of the 15 plurality of buck converter circuits, the control circuits also 16 adjusting relative duty cycles of the plurality of buck converter 17 circuits to balance the currents in the buck converter circuits 18

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interleaved buck converter circuits;

responsive to the difference in currents in the plurality of



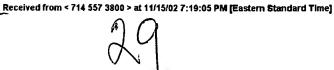
21	the plurality of pulse width modulators and the control
22	circuits being in a single integrated circuit.
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1	Mew) A DC to DC converter having a plurality of
2	converter circuits operating into a common load, comprising:
3	a plurality of buck converter circuits operating into the
4	common load, each buck converter circuit having an inductor for
5	alternately conducting between the first power supply terminal
6	and the common load, and the second power supply terminal and the
7	common load;
8	a plurality of pulse width modulators each controlling one
9	of the plurality of buck converter circuits, the pulse width
10	modulators being driven by a common oscillator signal so that the
11	operation of the pulse width modulators is interleaved;
12	control circuits for adjusting a nominal duty cycle of the
13	plurality of interleaved buck converter circuits to control a
14	voltage on the common load, and for adjusting relative duty
15	cycles of the plurality of buck converter circuits to balance the
16	currents in the buck converter circuits;
17	the plurality of pulse width modulators and the control

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circuits being in a single integrated circuit.







1	(New) A DC to DC converter having first and second
2	buck converter circuits operating into a common load, comprising:
3	first and second buck converter circuits operating into the
4	common load, each buck converter circuit having an inductor for
5	alternately conducting between the first power supply terminal
6	and the common load, and the second power supply terminal and the
7	common load;
8	a first pulse width modulator controlling the first buck
9	converter circuit;
10	a second pulse width modulator controlling the second buck
11	converter circuit;
12	a feedback circuit responsive to the voltage across the
13	common load;
14	control circuits for controlling the first and second pulse
15	width modulators responsive to the feedback circuit;
16	the control circuits also being responsive to current
17	measurements in the first buck converter circuit and the second
18	buck converter circuit to adjust the relative duty cycle of the
19	first and second pulse width modulators to balance the currents
20	in the buck converter circuits;
21	the first pulse width modulator, the second pulse width
22	modulator and the control circuits being in a single integrated





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_	<u></u>	(New) A DC to DC converter having a plurality of
	2	converter circuits for operating into a common load, comprising:
	3	a plurality of buck converter circuits operating into the
	4	common load, each buck converter circuit having an inductor for
	5	alternately conducting between the first power supply terminal
	6	and the common load, and the second power supply terminal and the
	7	common load;
\ 1	2 B	a plurality of pulse width modulators driven by a common
١~	9	oscillator in an interleaved manner, each pulse width modulator
	10	controlling one of the plurality of buck converter circuits,
	11	whereby the operation of the buck converter circuits is
	12	<pre>interleaved;</pre>
	13	a feedback circuit responsive to a voltage across the common
·×	14	output;
	15	a voltage control circuit controlling the plurality of pulse
	16	width modulators responsive to the feedback circuit and a
	17	commanded output voltage;
	18	the plurality of pulse width modulators and the control
	19	circuits being in a single integrated circuit.
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59. (New) The DC to DC converter of claim 58 further comprising the common oscillator, the common oscillator also being in the single integrated circuit.

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		1	50 68. (New) A DC to DC converter having a plurality of
		2	converter circuits operating into a common load, comprising:
		3	a plurality of buck converter circuits operating into the
		4	common load, each buck converter circuit having an inductor for
	l h	5	alternately conducting between the first power supply terminal
		6	and the common load, and the second power supply terminal and the
		7	common load;
		8	a plurality of pulse width modulators each controlling one
		9	of the plurality of buck converter circuits, the operation of the
		10	pulse width modulators and the buck converter circuits being
,		11	<pre>interleaved;</pre>
		12	a feedback circuit responsive to a voltage across the common
		13	load;
\		14	control circuits responsive to the feedback circuit and a
/		15	commanded output voltage to control a nominal duty cycle of the
		16	plurality of buck converter circuits;
		17	the plurality of pulse width modulators and the control
		18	circuits being in a single integrated circuit.
		1	59 &1. (New) The DC to DC converter of claim 60 further
1	9	2	comprising the common oscillator, the common oscillator also
, `	_	3	being in the single integrated circuit.

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62. (New) A DC to DC converter comprising:

first and second buck converter circuits operating into a

3 common load, each buck converter circuit having an inductor for

4 alternately conducting between the first power supply terminal

5 and the common load, and the second power supply terminal and the

6 common load;

first and second pulse width modulators driven by a common

8 oscillator in an interleaved manner, each pulse width modulator

controlling a respective one of the first and second buck

converter circuits, whereby the operation of the buck converter

11 circuits is interleaved;

a feedback circuit responsive to a voltage across the common

13 output;

a voltage control circuit controlling the first and second

pulse width modulators responsive to the feedback circuit and a

16 commanded output voltage;

17 the plurality of pulse width modulators and the control

18 circuits being in a single integrated circuit.

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6 (New) The DC to DC converter of claim 62 further

comprising the common oscillator, the common oscillator also

being in the single integrated circuit.

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64. (New) A DC to DC converter comprising:

first and second buck converter circuits operating into a

3 common load, each buck converter circuit having an inductor for

alternately conducting between the first power supply terminal

5 and the common load, and the second power supply terminal and the

6 common load;

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first and second pulse width modulators each controlling a

8 respective one of the buck converter circuits, the operation of

the pulse width modulators and the buck converter circuits being

10 interleaved;

a feedback circuit responsive to a voltage across the common

12 load;

control circuits responsive to the feedback circuit and a

14 commanded output voltage to control a nominal duty cycle of the

15 plurality of buck converter circuits;

the plurality of pulse width modulators and the control

17 circuits being in a single integrated circuit.

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65. (New) The DC to DC converter of claim & further

comprising the common oscillator, the common oscillator also

being in the single integrated circuit.

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